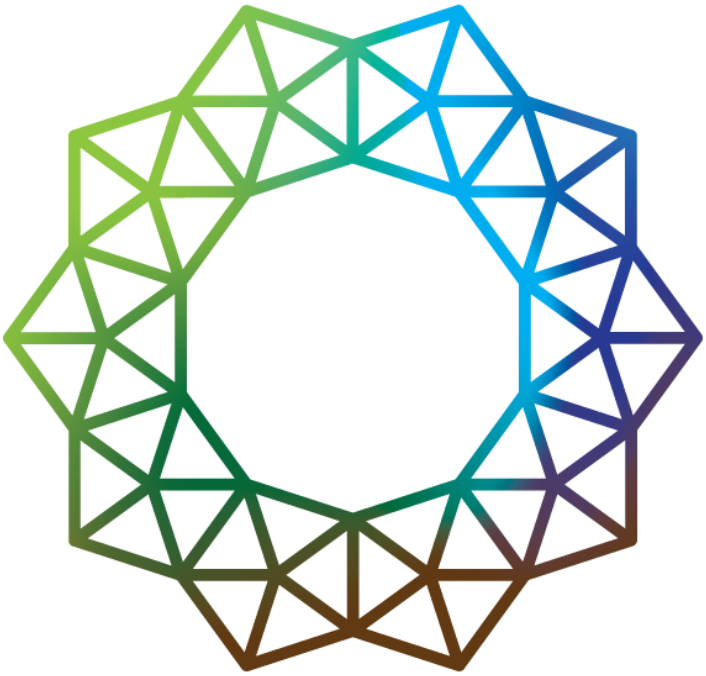

AMERIFLUX

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Sept 20 – Session: Water

Keynote Talk: **Transpiration of trees and forests using the SAPFLUXNET database: from species-level water use strategies to the quantification of ecosystem transpiration**

Dr. Rafael Poyatos López, SAPFLUXNET initiative, Centre de Recerca Ecològica i Aplicacions Forestals, Universitat Autònoma de Barcelona

Transpiration is a major component of global water balance and a key process underlying vegetation function and dynamics. However, estimating ecosystem transpiration, partitioning the contribution of different species, and quantifying species-specific variation in transpiration regulation in response to environmental variation are challenging with the common methods applied to quantify land evaporative fluxes. SAPFLUXNET (http://sapfluxnet.creaf.cat/) provides the first harmonized global database of sap flow measurements, designed to investigate the spatiotemporal dynamics of whole-tree transpiration, and encompassing 202 datasets and 175 species. Here, I will provide some examples of how SAPFLUXNET is being used to address key questions about plant drought responses and forest transpiration quantification.

Trends and developments in water flux partitioning at ecosystem scale

Jacob A Nelson, Max Planck Institute for Biogeochemistry

Methodologies for estimating the individual components of total ecosystem evaporation, such as transpiration, soil evaporation, and evaporation of canopy intercepted water, has seen rapid developments in recent years. Advances in both empirical and proceased based methods for estimating component fluxes, as well as strategies for validation given the limited availability of ground truth datasets, have produces a rich landscape of tools to study ecohydrology. This presentation outlines key recent advances in water flux component estimates, as well as potential future developments and links to remote sensing which will allow for the link from ecosystem to global scale.

Thermal remote sensing for terrestrial ecosystem science

Mallory L. Barnes *[1], Martha M. Farella [1], Joshua B. Fisher [2,3]

[1] Indiana University Bloomington [2] Hydrosat Inc. [3] Chapman University

Recent and emerging advances in thermal remote sensing data resolution, availability, and analytics present a timely opportunity for scientists studying carbon and water fluxes. Remote sensing in the thermal infrared (TIR) domain can offer novel insights into the impacts of changing surface temperatures on vegetation and associated ecosystem responses at multiple levels of organization. At the leaf-level, TIR can be used to derive stomatal behavior, identify plant traits, and differentiate between species. Remotely-sensed temperature anomalies at the canopy-scale can identify plant stress in near real-time. Regionally and globally, TIR remote sensing help address open questions related to photosynthetic acclimation, water use efficiency, and evapotranspiration in a warming world. Scaling leaf traits, canopy structure, and regional patterns requires an integrated understanding of both process and technology. We introduce a unifying framework to link leaf to globe through thermal remote sensing, outlining specific opportunities where thermal imagery could complement eddy covariance measurements of carbon and water fluxes. Incorporating thermal data into flux syntheses and upscaling efforts could be especially important to advance understanding of the impacts of climate change on vegetation from leaf to globe.

Combining ECOSTRESS, CubeSats and footprint modelling to improve the estimates of evaporation in Corn and Alfalfa fields

Camilo Rey-Sanchez*[1,2], Kaniska Mallick[1,3], Tianxin Wang[1], Joseph Verfaillie[1], Daphne Szutu[1], Dennis Baldocchi[1]

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The increasing availability of high-resolution (spatial and temporal) remote sensors provides important information for evaporation models. In particular, CubeSats offer information on vegetation biophysical status at the daily scale and at 3 m spatial

resolution. In this study we evaluate the improvement of evaporation estimates from the ECOSTRESS mission by assimilating data at three different spatial scales, 30 m from Landsat, 10 m from Sentinel, and 3 m from CubeSats. We evaluate the estimates against latent heat flux measurements from 2 eddy covariance towers, at a corn and alfalfa site, and further assessed the necessity of using footprint-weighted averages of evaporation at the different spatial resolutions. We also developed improved model parameterizations of radiation partitioning thanks to detailed field measurements of intercepted photosynthetically active radiation at both alfalfa and corn fields. In addition, we conducted analysis of the scale of the coefficient of variation across multiple scales to identify the adequate resolution to capture the most relevant scale of spatial heterogeneity. Our study revealed that information at the Cubesat level is important to detect small differences in photosynthetic capacity within homogeneous crops such as crop and alfalfa. We also found that the phenology of corn establishes a hysteresis in the growing season spectral response detected by high resolution vegetation indices, such as NDVI, EVI and NIR. The results of this study can be used to achieve precise estimates of evaporation at the diurnal and seasonal scale, relevant for modelling and crop irrigation management.

Sept 21 – Session: Natural Climate Solutions

Keynote Talk: Dr. Caroline Normile
Bipartisan Policy Center

abstract tbd

Team Talk: Promoting forest carbon cycling resilience to disturbance: Lessons learned and management recommendations from the US-UMB and -UMd Ameriflux sites

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The deciduous forests of North America are increasingly affected by disturbances from insects, pathogens and extreme weather, resulting in an uncertain future for this century-long carbon (C) sink. Our student-led group presentation will draw from over two decades of research, including multiple experimental disturbance manipulations, at the University of Michigan Biological Station's US-UMB and US-UMd Ameriflux Core sites to ask: how resilient are deciduous forests to partial disturbance and what characteristics of a forest support C cycling and sequestration resilience following disturbance? We will also discuss how our findings could revise forest carbon management practices and help to prioritize disturbance mitigation. Among our most surprising findings is the observation that deciduous forests can experience high tree mortality of >50% without compromising their capacity to sequester C. In the short term, this resilience is tied to offsetting patterns of C uptake and loss and, in the longer-term, an increase in resource-use efficiency followed by a rapid replacement of vegetation loss. Secondly, we found that more complex and biodiverse deciduous forests exhibit greater levels of C cycling resilience, even at relatively high disturbance severities. Lastly, continuous decades-long observations show that a transition from early to mid-late successional canopy tree species increases, rather than decreases, forest C

sequestration, a finding that is counter to popular theory. In practice, these findings suggest that forest managers should: recognize that disturbances have variable effects on C cycling resilience, with some effects short-lived; enhance C sequestration stability by cultivating biodiverse compositions and complex forest structures; and, preserve old forests as a way of sustaining the region's C sink and maintaining other critical goods and services tied to natural climate solutions.

Combining Remote Sensing Models and Eddy Covariance to Monitor Natural Climate Solutions in Agricultural Production Systems

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Natural climate solutions (NCS) are at the forefront of climate crisis debates, demanding change in ecosystem management to reduce and/or mitigate greenhouse gas emissions. Monitoring the success of such strategies, specifically changes in ecosystem carbon stocks, is subject to high uncertainty and often constrained by regional climate, soil type and management intensity. We tested if the combination of eddy covariance (EC) and remote sensing (RS) techniques could be used to improve NCS monitoring in agroecosystems by overcoming limitations of spatial and temporal resolution via RS and financial costs via EC. We used the environmental response function (ERF) approach to test if EC net ecosystem exchange of CO2 (NEE) measurements can constrain RS gross ecosystem exchange (GEE) and ecosystem respiration (Reco) models by updating model parameters like the maximum quantum yield of photosynthesis (φm). Daily EC NEE sums matched Landsat RS results when daytime data were compared (slope and R2 increased from 0.34 to 0.77 and 0.8 to 0.88, respectively), as Landsat measures during daytime periods. Daily EC NEE, GEE and Reco were in good agreement with RS models (R2 0.78-0.94, 0.86-0.95 & 0.74-0.89), however EC Reco & GEE were 60-115% of RS estimates, suggesting that both fluxes are generally overestimated using RS during the day. Soil respiration and Reco comparisons were in good agreement but EC Reco was again of lower magnitude (slope 0.5 versus 0.8 from RS). Nevertheless, annual biomass budget predictions from RS and EC fusion improved for all crop types when compared to field harvest biomass estimates (R2 = 0.6 and slope improved from 1.09 to 0.98). Our results suggest that EC RS fusion products can help improve the monitoring of NCS on much larger spatiotemporal scales compared to EC and RS methods alone but key uncertainties in Reco still need to be addressed.

Team Talk: Examining Climate Mitigation Practices at the Ecosystem Scale: Carbon Cycling, Methane Uptake, Evapotranspiration and Phenology Responses to Compost Application in a Grazed Grassland

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Compost amendments to grasslands could be an important tool for climate change mitigation, accounting for ~9% of the cumulative greenhouse gas (GHG) reductions required for CA state's ambitious goal of 147 MMTCO2e by 2030. Previous studies in compost-amended rangelands showed elevated soil respiration that was offset by increased net primary productivity and bulk soil organic carbon. Compost amendments had no significant effect on CH4 emissions, but generally increased soil water holding capacity. While these previous studies show promising results for compost amendments as a climate mitigation practice, more studies are needed to determine how compost applications function in diverse grasslands and at larger scales. Our team applied a one-time compost application to 1.6 ha of grazed grassland in 2020. An eddy covariance tower (US-CGG) monitored the grassland for the year before and following the amendment. Soils were sampled in both years and are being processed for bulk soil C and N. Static soil chambers were used to monitor soil surface CO2 and CH4 flux within the footprint of the tower. The compost amendment stimulated high GPP, however high Reco offset all enhanced CO2 uptake resulting in no significant difference in annual NEE between the 2 years. Phenocam data show that the compost amendment changed the phenology of the ecosystem leading to earlier green-up relative to control areas. Finally, compost-amended soils had significantly greater CH4 uptake compared to control soil. We hypothesize that higher soil moisture and nutrients in amended soils facilitates a larger methanotroph community. Future work will include analyses of the soil bulk C and microbial community as well as implications of changing soil moisture content for ET. These data will help inform the scale-emergent properties of soil amendment applications, an important climate mitigation practice that is planned to be used at large scales in CA and beyond.

Sept 22 – Session: Open Science

Priorities for synthesis in ecology and environmental science

Ben Halpern, National Center for Ecological Analysis and Synthesis

abstract tbd

Team Talk: Urban eddy-covariance: Why, how and where?

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Eddy-covariance has been used to study land-atmosphere fluxes for decades. Flux towers are typically deployed in relatively homogeneous ecosystem settings. Flux towers have been deployed in urban and suburban settings, but their integration into emerging efforts to quantify urban greenhouse gas (GHG) emissions with urban atmospheric inversions has been limited. We present the logic and methodology for flux tower deployments as a component of urban GHG studies. We present a synthesis of results that demonstrate these methods, drawing from the Indianapolis Flux Experiment (INFLUX) and Northeast Corridor (NEC) study. We present decomposition of total CO2 fluxes into anthropogenic and biogenic components using CO : fossil CO2 ratios, flux footprint decomposition at high spatial and temporal resolution to evaluate urban flux models in regions of heterogeneous emissions, and targeted observations of regional ecosystem fluxes. We show applications of these methods to quantify traffic-related flux changes resulting from the spring 2020 COVID lockdown. We describe how urban flux towers can be a valuable element of the overall “bottom-up” approach to determining urban GHG fluxes. We also illustrate the utility of these observations for improving the simulation of boundary layer turbulence required for urban atmospheric inversions.

Drought-induced decoupling between tree growth and carbon uptake impacts forest carbon turnover time

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The ability of forests to withstand, and recover from, drought stress is a critical uncertainty regarding the impacts of climate change on the terrestrial carbon (C) cycle. Quantifications of drought resistance and resilience are largely based on either direct

measurements of tree growth or broader-scale proxies for C uptake, but it is unclear how drought responses scale from individual trees to forests. Understanding the nature of this scaling is crucial to quantify the degree to which drought impacts the C cycle through changes in uptake versus turnover time. Here, we document a widespread decoupling in drought responses across C cycle processes, whereby gross primary productivity (GPP) was relatively resistant to drought despite highly sensitive co-located tree-ring chronologies. For example, annual GPP was infrequently significantly reduced due to drought, while tree ring width decreased on average by 25% during the drought year, and 20% in the year after drought. By modeling whole-forest C turnover time, we show this decoupling has important ramifications for the forest C cycle, especially if C is allocated towards foliar or non-structural pools with short residence times. Indeed, our modeled decreases in forest C turnover due entirely to allocation shifts represent a sizeable fraction of the current trend in turnover due to tree mortality. Our results demonstrate that quantifications of drought impacts that rely on C uptake are missing this fundamental pathway through which drought alters the forest C cycle.

Team Talk: The FLUXNET Coordination Project: A new initiative to support global network-enabled science

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Global ecosystems provide services that sustain society, including provisioning of food, ber and timber, and water cycle regulation. Understanding ecosystem-atmosphere interactions, and the response of these to ongoing environmental change, is thus an urgent challenge. The FLUXNET Coordination Project will ll fundamental knowledge gaps in science, engineering, and societal issues associated with ongoing changes in ecosystem function and the related cycling of carbon and water. FLUXNET is a global network of regional networks, consisting of scientists measuring the exchange of carbon dioxide, water, energy, and other greenhouse gas fluxes between ecosystems and the atmosphere. Such measurements have proven essential for understanding ecosystem function, calibrating space-borne observations, and developing models used to project future climate. The project links over ten existing national and international networks focused on continuous observations of ecosystem-atmosphere interactions at over 1000 locations around the world. Through multiple research and training opportunities it will help develop the next generation of the FLUXNET network-of-networks to be a self-sustaining global collaboration focused on supporting early career scientists, expanding the diversity of scientists, biomes, and climate regions involved, and empowering international collaboration. The central goals of the FLUXNET Coordination Project are

to provide novel training and exchange opportunities, develop strong international collaborations, and build tools and protocols that ensure continued growth of FLUXNET beyond the life of the project. To do so, the project will develop both data-focused processing protocols and pipelines, and people-focused education and exchange opportunities. Here, we give an overview of the project, including various opportunities for involvement and activities planned for the coming year.

- Poster abstracts -

Topic: Water
Poster session on: Mon
Poster #1

Surface-atmosphere interactions across ecological succession in tropical dry forest.

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Ecosystem dynamics in the carbon and water cycles are changing in response to current climate change in addition to constant land-use change that threatens these tropical biomes. The tropical dry forest is constantly being disturbed, creating a mosaic of successional stand-stages, which fosters ecosystem complexity along succession. Since evapotranspiration is the process linking the water cycle with ecosystem function, we investigate the differences in forest structure parameters and evapotranspiration during the wet season (Jun-Nov, from 2016 to 2020) at a tropical dry forest in northwestern Mexico, to elucidate how different stand ages are coupled to the atmosphere and how surface-atmosphere processes may vary. We present eddy covariance data from a successional gradient of tropical dry forest; an early (~9 years; ESF), a mid-successional (~45 years; MSF) secondary forest and an old-growth forest (OGF). Our results show that the least decoupled site to the atmosphere was the MSF, followed by the OGF and the ESF; while the aerodynamic conductance was alike during the study period in the MSF but varied in the OGF. In terms of albedo, the energy absorbed by the surface was constant in the OGF and MSF but varied significantly in the ESF. We found that evapotranspiration was alike at all sites and close to the precipitation input each year. During dry years the lifting condensation level was higher than during wet years, wet/dry years were determined based on historic precipitation information. We conclude that the synergy between different structural parameters at each site influence the evapotranspiration and surface-atmosphere interactions, being the ESF the most sensitive ecosystem to water availability and exchange followed by the OGF and the MSF.

Topic: Natural Climate Solutions
Poster session on: Wed
Poster #2

The Influence of Interannual Carbon Variability on Long-Term Carbon Sequestration in Proximate Northern Forests and Wetlands

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Carbon dioxide (CO2) levels have been shown to be rising dramatically as a result of increased anthropogenic activity. One way of countering excessive CO2 emissions is by restoring natural ecosystems that have historically been found to be efficient carbon sinks. In order to be economically viable, these efforts must consider biomes with long-term sustained carbon sequestration capacities. Low interannual variation in this sink capacity minimizes risk of sequestration reversal. The goal of this study was to compare the interannual variability of carbon at four proximate Ameriflux eddy covariance sites across northern Wisconsin and Michigan's upper peninsula with up to two decades of observations per site. Two wetlands (Allequash Creek (US-ALQ) and Lost Creek (US-Los)) and an unmanaged and managed forest (Sylvania Wilderness Area (US-Syv) and Willow Creek (US-WCr), respectively) were considered. To consider the fuller carbon budget for wetlands, we also incorporated stream discharge data from the United States Geological Survey. In most of the measured years, on average, NEE in both types of ecosystems was negative (carbon uptake by the ecosystem). US-ALQ and US-Los had a yearly averaged standard deviation of ~4.3 µmol CO2 m-2 s-1, while for US-Syv, and US-WCr it was ~5.5 and ~6.3 respectively, implying greater variability for the forests than wetlands. Interannual water availability (precipitation and discharge) was the main driver for wetland carbon variation while radiation was the best predictor of carbon dynamics in the forests. Our results demonstrate that for this region, wetlands are a more reliable biome for carbon storage on decadal scale than forests. In addition, this capacity may be enhanced through restoration efforts focusing more on water availability rather than afforestation/reforestation.

Topic: Natural Climate Solutions
Poster session on: Mon
Poster #3

Global variation in ecosystem carbon use efficiency derived from eddy covariance observations

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Carbon use efficiency (CUE) indicates the fraction of carbon assimilated by photosynthesis that is fixed in plant biomass. Recent advances have demonstrated that CUE varies across space and time, however, the reason of which remains debated (e.g., the impact of temperature on CUE). The lack of knowledge on CUE variations is caused by the limited number of observations globally, as CUE measurements require strenuous field survey of biomass change and allometry. In this study, we use high quality land-atmosphere CO2 exchange records of ~1000 site-years from open access eddy covariance datasets (i.e., Fluxnet2015, ONEflux) to infer CUE and investigate its variation. The inferred CUE closely correlates with inventory-based CUE observations ($R2 = 0.64$, $p<0.01$), and distributes around 0.46 ± 0.12. Our results reaffirm that CUE has large spatial and temporal variations, and find CUE is negatively related to temperature, light and stand age. Importantly, we find there is a difference in the baseline CUE of deciduous and evergreen forests. Our study provides insights into the carbon fixation efficiency of plants, which can guide decision-makings on world reforestation efforts as a part of nature-based climate solutions.

Topic: Natural Climate Solutions
Poster session on: Wed
Poster #4

CO2 fertilization effect on photosynthesis inferred from observations using optimization theories

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Global photosynthesis is increasing with elevated atmospheric CO2 concentrations, a response known as the CO2 fertilization effect (CFE), but the magnitude of CFE remains uncertain. We quantify CFE by combining observations from a globally distributed eddy covariance measurement network with a novel mechanistic attribution framework. The framework is based on three eco-evolutionary optimization theories that analytically couples the carbon and water exchange processes. We report the first direct observational evidence for the dominant effect of CO2 on gross primary production (GPP) enhancement since the 2000s, with additional other contributions primarily from warming. Soil moisture and specific humidity are the two largest contributors to GPP interannual variation through their influences on plant hydraulics. We also apply this process-based, theory-driven framework to scale up CFE globally using remotely sensed green leaf area and reanalysis data, suggesting a higher-than-expected CFE in tropical forests, which is unobserved in many remote sensing GPP products that omit the direct CFE on gas exchange. These results highlight the critical role that CFE has had on the global carbon cycle in recent decades.

Topic: Open Science Session
Poster session on: Mon
Poster #5

Water vs. energy: controls on the sensitivity of gross primary productivity to drought

David L. Miller *[1], Trevor F. Keenan [1][2], Sebastian Wolf [3], Joshua B. Fisher [4]; [1] University of California Berkeley, [2] Lawrence Berkeley National Laboratory, [3] ETH Zürich, [4] University of California Los Angeles

Gross primary productivity (GPP) is the initial product of plant photosynthesis at the ecosystem scale and is controlled by many meteorological factors. Precipitation, temperature, and solar radiation all influence GPP, but due to differences in water and energy limitations, the sensitivity of GPP (i.e., direction and magnitude of slope) to these factors can vary widely across terrestrial ecosystems. The breadth of these responses can lead to apparent contradictory behavior. With warmer and drier drought conditions at the height of the growing season, GPP typically decreases, but there also exist ‘anomalies’ in which GPP increases with warmer and drier conditions for certain sites and seasons. Here, we develop a systematic framework to characterize the competing sensitivities of GPP to meteorological forcings related to drought, providing context for presumably outlying cases of GPP response along a gradient of aridity. We base the core of our analysis on long-term eddy covariance site data across an array of temperate climates contained in the FLUXNET2015 dataset. For individual eddy covariance sites, we calculate GPP sensitivities and assess the representation of GPP sensitivity relationships within carbon model outputs. To test these relationships across broader spatial scales, we assess the response of GPP for different seasons using gridded climate data (e.g., WorldClim 2.1) and GPP products (e.g., MODIS GPP) as training and comparative validation, respectively. Characterizing and mapping spatial patterns in GPP sensitivities is needed to be able to describe how different ecosystems are likely to respond to meteorological shifts due to climate change, and this study demonstrates the interacting and sometimes contrasting effects of droughts on GPP.

Topic: Water
Poster session on: Wed
Poster #6

Resolve the continuous diurnal cycle of high-resolution ECOSTRESS Evapotranspiration (ET) and Land Surface Temperature (LST)

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Remotely sensed evapotranspiration (ET) is well established, yet a diurnally-resolved product with high spatial resolution (<100 m) is still lacking, which is critically needed for agricultural and ecosystem monitoring but impossible with existing technology. The ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) provides, for the first time, land surface temperature (LST) and ET at 70m spatial resolution with diurnal samplings, enabling a promising opportunity to fill this data gap. This study developed the first framework to resolve the full diurnal cycle of LST and ET from temporally sporadic ECOSTRESS measurements. We first constructed the diurnally-resolved 70m ECOSTRESS LST using a diurnal temperature cycle (DTC) model in conjunction with Geostationary Operational Environmental Satellite (GOES) LST. Next, we derived the 70m ECOSTRESS diurnal ET from that of LST, along with ancillary meteorological and surface reflectance datasets, using the Priestley-Taylor Jet Propulsion Laboratory (PT-JPL) algorithm. Our diurnally-resolved LST and ET successfully reproduced the spatial variation exhibited in the native ECOSTRESS measurements during overpasses (correlation coefficient r>0.96 for LST, r>0.99 for ET). Furthermore, the constructed time series captured the in situ diurnal variation in LST (r=0.91-0.99) and ET (r=0.47-0.70) measured at a semi-arid grassland flux tower (US-Seg) across distinct phenological stages. In addition, we tested our framework under different weather conditions, and found overall great agreement under clear sky, but degraded performance on cloudy/rainy days due to reduced data availability/quality as well as modelling bias. Finally, caveats and future refinement of the framework were discussed. This pilot study sets the stage for testing and applying our framework to broader climates and biome types towards eventually generating diurnally-resolved 70m global operational LST and ET products, holding great potential in enhancing ecological and agricultural applications.

Topic: Natural Climate Solutions
Poster session on: Mon
Poster #7

Unpacking the drivers of diurnal dynamics of sun-induced chlorophyll fluorescence (SIF): Canopy structure, plant physiology, instrument configuration and retrieval methods

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Sun-induced chlorophyll fluorescence (SIF) from satellites is a promising tool for monitoring regional crop productivity, but its application is constrained by insufficient understanding of the diurnal dynamics of SIF. Ground-based SIF data can reveal diurnal SIF dynamics across biomes and environmental conditions; yet, meaningful interpretation requires disentangling impacts from canopy structure, plant physiology, instrument configuration and retrieval methods, which often interact and may confound each other. We unpacked these drivers using 1) concurrent canopy- and leaf-scale measurements at an agricultural corn field; 2) a mechanistic SIF model that explicitly considers the dynamics of photochemistry (via the fraction of open photosystem II reaction centers, qL), photoprotection (via nonphotochemical quenching, NPQ), and their interactive dependence on sub-canopy light; and 3) cross-comparison of SIF instrument configuration and retrieval methods. We found that combinations of crop row orientations and sun angles can cause a distinctive midday dip in SIF in absence of stress, due to a midday drop of absorbed photosynthetically active radiation (APAR) when crop rows are north-south oriented. This influenced sub-canopy qL and NPQ at different points within the vertical canopy that affected fluorescence quantum yield (ΦF) at the leaf scale. Once integrated at the canopy scale, diurnal dynamics of both APAR and canopy escape probability (ε) are critical for accurately shaping diurnal SIF. While sub-canopy qL and NPQ exhibited strong diurnal dynamics at the leaf level, their influence was attenuated at the canopy scale due to opposing effects on SIF at different canopy layers. Different system configurations and retrieval methods can also affect magnitude and diurnal shape of SIF, thus confounding the interpreted strength and dynamics of SIF emission. Our findings show the importance of crop rows, interactive variations in canopy structure and plant physiology, instrument configuration, and retrieval method in shaping measured diurnal SIF dynamics. This study highlights the necessity to account for these factors to accurately upscale satellite SIF from instantaneous to daily integrals and informs future synthesis work with different SIF instrumentation and retrieval methods across sites.

Topic: Water
Poster session on: Wed
Poster #8

Energy flux over snow during melt season

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Food is watered by snow. Not only do mountains generally receive higher amounts of total precipitation than surrounding lowlands but they also provide natural storage of water in form of snow. The temporal alignment of melt and growing season is unsurprising --- both are functions of temperature --- but not inevitable as plant phenology depends on many coincident factors. High elevation and high latitude regions (i.e., the snowiest regions) are predicted to experience more extreme impacts of climate change. The implications on snow water storage under a warming climate are frightening: less overall water and earlier melt seasons offset from peak agricultural need.

Here, we use flux tower data from several AmeriFlux sites (Niwot Ridge, University of Michigan Biological Station, Blodgett Forest, and Southern Sierra Critical Zone) with seasonal snow to observe the energy balance during snow accumulation and melt periods. We examine how the energy balance changes throughout the course of a winter season and attempt to identify significant transitions between different processes in the season from the energy records. We also compare results from evaluating energy flux terms with snow data from a co-located Snow Telemetry (SNOTEL) station and from remote sensing data of the same region. For sites with no SNOTEL station, we use a Landsat-based snow reanalysis product in the Sierra Nevada and MODIS snow cover products for other regions.

We find that flux tower energy measurements generally align with independent snow observations during the melting season. Further, tracking energy flux can indicate snow warming and ripening before melting occurs. Lastly, previous work has suggested wind scour as a key factor in snow removal at Niwot Ridge and other vegetation-free sites. We investigate a correlation between flux tower wind speed and misalignment between SNOTEL and energy balance-based estimations and show preliminary results.

Topic: Water
Poster session on: Mon
Poster #9

The Ecosystem Wilting Point: An Integrated Functional Property Determining Drought Responses

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Drought is a pervasive threat to global productivity. Developing an improved understanding of how ecosystems respond to drought is thus crucial towards predicting responses to climate change and developing mitigation and risk management strategies. While there has been much progress in understanding how drought affects whole-plants and their constituent tissues, ecosystem-scale responses remain, to a certain extent, a “black box”. We used observations from the major 2012 drought to examine the whole-ecosystem drought response, combining eddy covariance and community predawn leaf water potential (Ψpd) measurements. We employed an ecosystem-scale analog to the classic pressure-volume technique to derive the ecosystem wilting point (ΨEWP) of a Quercus-Carya (oak-hickory) forest. The ΨEWP is an ecosystem functional property that integrates above and belowground processes, and plays a central role in determining whole-ecosystem drought responses. In principle, ΨEWP accounts for the interplay between the ability of the root system to extract soil water, with the capacity for leaves to maintain turgor and sustain stomatal conductance. We find that this forest, which has an ΨEWP of −2 MPa, is often operating such that severe physiological water stress (i.e., ΨPD < ΨEWP) can be induced by transient droughts of only 2 weeks in length. We believe that synthesis of ΨEWP across sites will help to better understand the biogeographical distribution of ecosystems.

Topic: Open Science Session
Poster session on: Wed
Poster #10

Partitioning net ecosystem exchange (NEE) of CO2 using Solar-Induced chlorophyll Fluorescence (SIF)

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Accurate partitioning of net ecosystem exchange (NEE) of CO2 to gross primary production (GPP) and ecosystem respiration (Reco) is crucial for understanding and predicting the dynamics of carbon cycle under changing climate. However, it represents a long-standing open problem in global ecology, due to a lack of independent constraining information for the two offsetting component fluxes. Solar-Induced chlorophyll Fluorescence (SIF), a mechanistic proxy for photosynthesis, holds great promise to improve NEE partitioning by constraining GPP. This study developed a novel SIF-based approach for NEE partitioning, and examined its performance using simulated and field measurements. We found that this approach outperforms conventional approaches in reproducing the simulated true GPP and Reco components. For field measurements, it results in lower daytime GPP and Reco than conventional approaches especially under high VPD. Our results provide the first evidence that SIF could improve the accuracy and robustness of NEE partitioning under real world environmental conditions.

Topic: Water
Poster session on: Mon
Poster #11

Assessing snow interception in a subalpine forest using image detection compared to model estimates

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Canopy snow interception is an important process for energy and water cycling in many forests world-wide. In-situ measurements of snow interception, however, are impractical since instruments are labour-intensive to install and monitor, expensive and seldom applicable at scales greater than a single tree. This has led to the potential use of time-lapse photography to detect the presence of snow interception at the canopy scale. Use of snow interception data provided by time-lapse photography can then be used to test models that simulate snow interception. In this study, snow interception as detected from PhenoCam time-lapse cameras installed above a subalpine forest site (AmeriFlux site US-NR1) in the Rocky Mountains of Colorado were analysed during a four-week period in January 2019. A pixel classification procedure was developed in MATLAB and compared to interception as simulated using a simplified section of the Community Land Model (CLM) (Version 5.0).
Several storm events occurred throughout the month, delivering a measured total of 85.9 mm of precipitation, all of which fell as snow based on temperature analysis. Of this, 57.3 mm was modelled as being intercepted. During a single snowfall event, after accounting for unloading, the maximum amount of snow stored in the canopy was simulated at 8.2 mm. Preliminary results showed the pixel classification procedure was able to identify interception events as modelled by CLM. Large and prolonged modelled interception events were more likely to be confirmed by the Phenocam image analysis, as interception events can only be captured by the Phenocams during daylight hours.
The inability of photography to capture snow interception dynamics during the night, sunrise and sunset reduced the temporal extent of the PhenoCam data for this purpose. Lowlight conditions also proved problematic, however, the constantly changing exposure of the Phenocam photographs was addressed by automatically adjusting to a base exposure.
Although Phenocam images can be used to identify interception when focused on the canopy of a subalpine forest, with results comparable to modelled interception, there are issues with using the Phenocam images, namely the need for good light conditions and the need to adjust for the constantly changing image exposure.

Topic: Open Science Session
Poster session on: Wed
Poster #12

From half-hour to quarter century: Drivers of carbon fluxes across a northern ecosystem tower cluster

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Long-running eddy covariance towers help provide the statistically robust insights into how the carbon cycle operates over multiple time-scales, across multiple climate extremes, disturbances, and during long-term trends in atmospheric composition. Long-running eddy covariance towers operating as a cluster provide an even stronger case for evaluating how processes that impact the carbon cycle vary across ecosystem properties, within the same climate and biome. Here, we present a lab initiated project to harmonize and evaluate variation in net ecosystem exchange of carbon dioxide across the Chequamegon Ecosystem-Atmosphere Study (ChEAS) Ameriflux core site cluster in the upper Great Lakes region USA. The tower network includes two mature hardwood forests with differing management regimes (US-WCr and US-Syv), two fen wetlands with varying exposure and vegetation (US-Los and US-ALQ), and a very tall (400 m) landscape level tower (US-PFa) that has been in continuous operation for eddy covariance since 1996. Together, they provide over 70 site-years of observations that can be coupled to climate drivers and remotely-sensed vegetation function. Short-term seasonal to 4-year studies of additional tower clusters in wetlands, forests of differing successional stage, and the 19-tower CHEESEHEAD19 campaign provide additional context on spatial variation. One remarkable consistent finding is the strong role that water, whether in atmosphere (VPD), soil, stream, or water table plays in modulating carbon flux variation, despite a general overall lack of water-limitation in the biome.

Topic: Open Science Session
Poster session on: Mon
Poster #13

Using uncertainty to decide among gap-filling methods

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Imputing missing values (i.e. gap-filling) is often required to derive annual sums and analyze long-term patterns in environmental measurement timeseries, since these datasets are prone to gaps from power outages, sensor malfunction, and quality control filtering. To meet this need, many gap-filling methods have been developed and tested on diverse datasets, including marginal distribution sampling (MDS), mean diel variation (MDV), regression with similar or replicate sensors, neural networks, and random forests, to name a few. Unfortunately, the performance of these and other methods is often specific to the dataset and can vary widely even within the same dataset. In addition, predictions from a particular method may not be available for all missing values if data requirements are not met. Thus, a combination of methods can be useful in gap-filling, but an objective decision framework is needed to select among multiple gap-filling predictions for each missing value. We present such a framework based on uncertainty, to date developing comparable uncertainty estimates for the MDS, MDV, and similar sensor regression methods. We tested the derived uncertainty estimates and the gap-filling decision framework on meteorological timeseries from NEON sites with simulated gaps ranging in size from ½ hour to 30 days. Preliminary results show that the derived uncertainty estimates are highly reliable for similar sensor regression at all gap sizes, while those for the MDV and MDS methods degrade somewhat a larger gap sizes although are still useful in the decision framework. Future work involves testing additional gap-filling methods in the uncertainty-based decision framework.

Topic: Open Science Session
Poster session on: Wed
Poster #14

Introduction of GeoNEX fixed sites subset over the conterminous US

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Satellite remote sensing data are important tool for extrapolating the knowledge obtained at the Fluxnet towers. We introduce our GEO-NEX geostationary satellite subset products, which make it easy to compare between ground observation and Geo-NEX products. The MODIS subset has been frequently used for validating ecosystem models developed at flux towers and upscaling the observed flux data to regional scales. However, MODIS on the polar orbiting satellites can observe target regions only once a day, while the Fluxnet eddy-covariance data are compiled as sub-hourly datasets. As a results, summarizing the sub-hourly flux data into daily statistics is necessary for the comparison between MODIS and Flux data. Here, the new generation geostationary satellite sensors (GOES-16/17 ABI and Himawari-8/9 AHI) has the high-frequent observation feature (10 minutes) in addition to similar spectral band and spatial resolution with MODIS. The high frequent observation allows us to compare the flux diurnal cycle with geostationary satellite sensor data. Some studies have already shown the effective utilization of time series of geostationary satellite data for ecosystem modeling. We are producing NEX Level-1G products, which is the gridded Top-of-Atmosphere reflectance and brightness temperature data of geostationary satellite sensors. We cut out the NEX Level-1G data using the same file format with the MODIS subset except for the projection. The other data products (e.g., surface reflectance, land surface temperature, vegetation indices and climate data) will be also added upon their availability. We selected the ground observation sites from Fluxnet, Phenocam, and AERONET networks. The NEX subset data will be provided through NASA NEX data portal.

Topic: Natural Climate Solutions
Poster session on: Mon
Poster #15

Application of the E3SM Land Model for Simulating Carbon Fluxes in an Amazonian Peatland

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Tropical peatlands are a major methane (CH4) source in global carbon budgets, but large uncertainties still persist in their estimates because of a lack of CH4 observations in the tropics. In 2017, we established an eddy covariance flux site in a natural palm swamp peatland near Iquitos, Peru (AmeriFlux site ID: PE-QFR; https://ameriflux.lbl.gov/sites/siteinfo/PE-QFR). The strong effects of hydrometeorological forcing on its carbon fluxes have been reported (Griffis et al. 2020). In the present study, we report the point-scale simulations of carbon fluxes in this peatland site with two years of flux data using the Energy Exascale Earth System Model (E3SM) land surface component (ELM), which is incorporated with a new mechanistic microbial-functional-group-based CH4 module (Ricciuto et al. 2021; Yuan et al. 2021). Our initial model testing for tropical peatlands demonstrated that simulations with default ELM algorithms were not sensitive to changes in soil water conditions and overestimated GPP in the dry seasons and consequently overestimated dry-season carbon dioxide (CO2) and CH4 fluxes compared with observations. Based on new field observations, several key algorithms were modified including: (1) soil hydraulic property functions involving a site-specific water retention curve with empirical tropical soil data; (2) dynamic function of leaf carbon-to-nitrogen ratio according to seasonal phenological and physiological changes of tropical species; and (3) water stress scalar function in CH4 processes, which is improved as a dynamic function of water table level. The revised ELM model showed significantly improved simulations of seasonal and diel carbon fluxes for this tropical peatland site. Uncertainty analyses of key model parameters related to biogeophysics and biogeochemical cycling were also conducted and provide new insights regarding the behavior and prediction of CO2 and CH4 fluxes in these unique peatland systems.

Topic: Water
Poster session on: Wed
Poster #16

Inter-annual groundwater variation affects ecosystem productivity

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Groundwater (GW) is a critical freshwater resource in water-limited environments. GW levels modulate more slowly and are less sensitive to precipitation than soil moisture. Thus, GW may act as an alternative long-term and large-scale water source to ecosystems even when surface conditions are dry. Despite its importance, ecosystem access to and reliance on GW is challenging to quantify.

In this study, we consider ecosystem reliance on GW by testing the hypothesis that GW-dependent systems are less productive when GW is scarce. We first use in-situ eddy covariance data from three semi-arid AmeriFlux sites to quantify ecosystem reliance on GW. A general addition model is built for each field site to account for meteorological variables that are known to affect gross primary productivity (GPP), including solar radiation, soil moisture, specific humidity, and air temperature. The models systematically over-predict GPP when GW is scarce. When GW drops below site-dependent critical thresholds, ecosystem productivity is diminished across the four sites, even when soil moisture anomalies are positive. A bucket model confirms our findings: GPP is significantly reduced under negative GW anomalies. The thresholds at which ecosystems respond to GW scarcity may be relevant to management and relate to mean maximum rooting depth. Our findings also highlight the need for increased attention to GW hydrology in predicting ecosystem resilience to drought.

Topic: Open Science Session
Poster session on: Mon
Poster #17

A footprint-informed decomposition approach for deriving flux response functions at AmeriFlux sites

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Eddy-covariance flux data are spatiotemporally dynamic. Global networks of eddy covariance towers provide the largest synthesized data sets of CO2, H2O, energy, and other GHGs fluxes. This includes FLUXNET and AmeriFlux data sets that have been widely used in many research and applications. While the eddy-covariance data are recognized for their rich temporal information, their spatially dynamic nature due to the varying source areas from time to time (i.e., so-called flux footprint) is often overlooked. As many flux tower sites are located in a more-or-less heterogeneous or patchy landscape, the spatial variations of land surface characteristics and the temporal dynamics of flux footprints jointly lead to the so-called representativeness issue, i.e., to what extent do the flux measurements taken at individual tower locations reflect the flux conditions of a specific land-cover or ecosystem type at all times. We developed a footprint-informed approach to decompose the response functions of CO2, H2O, and sensible heat fluxes at eddy-covariance sites. This approach incorporated the temporal dynamics of footprints and the spatial variations of land surface characteristics and was tested at selected AmeriFlux sites with different degrees of heterogeneity and patchiness. Our preliminary results showed that the approach was robust in decomposing flux response functions at sites with moderate heterogeneity and patchiness. And, the derived response functions can be used to inform fluxes at specific land-cover types within the flux footprints. The validity and uncertainty level of the flux decomposition approach depended on the degrees of heterogeneity and land-cover composition. Further tests and improvements will be conducted to better constrain the derivation of the response functions.

Topic: Open Science Session
Poster session on: Wed
Poster #18

Site characteristics mediate the relationship between forest productivity and satellite measured solar induced fluorescence

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Solar-Induced Chlorophyll Fluorescence (SIF) can provide key information about the state of photosynthesis and offers the prospect of defining remote sensing-based estimation of Gross Primary Production (GPP). There is strong theoretical support for the link between SIF and GPP and this relationship has been empirically demonstrated using ground-based, airborne, and satellite-based SIF observations, as well as modeling. However, most evaluations have been based on monthly and annual scales, yet the SIF:GPP relationship can be strongly influenced by both vegetation structure and physiology. Here, we test how well SIF can predict the inter-daily variation of GPP during the growing season and under stress conditions, while taking into account the local effect of sites and abiotic conditions. We compare the accuracy of GPP predictions from SIF at different timescales (half-hourly, daily, and weekly), while evaluating effect of adding environmental variables to the relationship. We utilize observations at 31 mid-latitude, forested, eddy covariance (EC) flux sites in North America and Europe and use TROPOMI satellite data for SIF. Our results show that SIF is a good predictor of GPP, when accounting for inter-site variation, probably due to differences in species composition and canopy structure. Seasonally-averaged leaf area index and canopy conductance provide a predictor to the site-level effect. We show that light saturation is the main factor driving errors in the linear model at high temporal resolution. Adding water stress indicators, namely VPD, LE, and canopy conductance, to a multi-linear SIF-based GPP model provides the best improvement in the model precision, showing the importance of accounting for water stress in GPP predictions, independent of the SIF signal. SIF is a promising predictor for GPP, but more focus should be placed on including canopy structure, water stress, and light saturation effects in the relationship, especially when considering intra-seasonal, and inter- and intra-daily resolutions.

Topic: Water
Poster session on: Mon
Poster #19

Breaking through the space-time barrier for remotely sensed evapotranspiration

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Land-atmosphere water fluxes are highly heterogeneous in space and time (e.g., < 100 m, daily/diurnal), yet we lack any cohesive approach to observe these scales beyond eddy covariance measurements. Remotely sensed ET can be constructed from a combination of measurements in the thermal infrared (TIR; e.g., land surface temperature), visible to near infrared (VNIR; e.g., greenness indices), and meteorology. While we have high spatiotemporal global VNIR (e.g., Planet), we do not have high spatiotemporal TIR, which dominates ET variability at high temporal frequencies. Current and planned missions either have high spatial resolution (e.g., Landsat, ECOSTRESS, ASTER; SBG, TRISHNA, LSTM) or high temporal resolution (e.g., MODIS, VIIRS, GOES), but not both. How can we break through this space-time barrier for remotely sensed ET?

Hydrosat has innovated through this barrier to achieve field-scale, global TIR data for ET and other Earth science applications every day, multiple times per day. With an upcoming launch en route to 16+ smallsat TIR satellites, Hydrosat data will be a game-changer and will significantly advance our monitoring and management capabilities for ecosystems, agriculture, and other applications. As with ECOSTRESS and other satellite missions, a strong partnership with AmeriFlux/FLUXNET will be mutually beneficial for addressing questions related to land-atmosphere water fluxes. This presentation introduces Hydrosat to the community, and invites new ideas of how to leverage these unprecedented data.

Topic: Water
Poster session on: Wed
Poster #20

Evaporation and transpiration across the seasonal transition from summer to winter at 17 eddy covariance research towers in a mixed forest landscape

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Global change is accelerating the hydrologic cycle and altering plant function, impacting evaporation (E) and transpiration (T) in multiple ways. T and E are poorly quantified because these fluxes are difficult to measure independently and are often measured as their sum, evapotranspiration (ET), using eddy covariance. Here, we use flux variance similarity (FVS) to partition E and T from eddy covariance-measured ET to understand how E and T respond to climate variability across multiple vegetation types. We used a FVS flux partitioning algorithm, Fluxpart, to estimate E and T in a diverse forested landscape in northern Wisconsin during the growing season and transition to winter using observations collected by the CHEESEHEAD19 research project. The study sites include 10 deciduous forests, 4 evergreen forests, and 3 wetlands/lakes, all of which undergo unique seasonal changes in vegetation structure with impacts on E and T that remain unclear. T was higher than E over the summer months and also decreased more than E as the season progressed in the forest ecosystems. Results suggest that E remains relatively constant through the study period, despite changes in phenology.

Topic: Water
Poster session on: Mon
Poster #21

Continuous observation of canopy water content changes with GPS sensors

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Canopy water content is a direct indicator of vegetation water use and hydraulic stress, reflecting how ecosystems respond and adapt to droughts and heatwaves. So far, in-situ estimates of vegetation water content often rely on infrequent and time-consuming samplings of leaf water content (or leaf water potential), which are not necessarily representative of the canopy scale. On the other hand, several satellite techniques have demonstrated a promising potential for monitoring vegetation optical depth and water content, but these large-scale measurements are still difficult to reference against sparse in-situ level observations.

Here, we present an experimental technique based on Global Navigation Satellite Systems (GNSS) to bridge this persisting scale gap. Because GNSS microwave signals are obstructed and scattered by vegetation and liquid water, placing a GNSS sensor in a forest and measuring changes in signal quality can provide continuous information on canopy water content and forest structure. We show that variations in GNSS signal attenuation reflect changes in both canopy structure and water content. Of particular interest, this technique appears sensitive enough to resolve the diurnal cycle of canopy water content. The rainfall and dew events captured during the observational record also suggest that canopy water interception (and dry-downs) can be monitored continuously. We discuss future strategies and requirements for deploying such cheap and practical bistatic radar systems at existing eddy-covariance sites.

Topic: Open Science Session
Poster session on: Wed
Poster #22

US-Me2- Preliminary assessment of ecosystem response one year post fire

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A mixed severity fire burned through the US-Me2 AmeriFlux Core site in August 2020. This fire had multiple ecosystem impacts, including variable bole and foliage scorching to foliage loss, tree mortality and changes to soil respiration dynamics. Eddy covariance, above and below ground hydraulic function and physiology, and soil respiration measurements were resumed shortly after the fire to quantify impacts on energy, water, carbon fluxes and stocks, as well as resilience and mortality at the tree, stand, and ecosystem scales. Here we present preliminary results of immediate and 1st year trends across burn severities.

Topic: Open Science Session
Poster session on: Mon
Poster #23

Eddy covariance methane and carbon dioxide flux to and from north-temperate bog lakes: can the machine learn the processes that control spring and fall pulses?

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The northern temperate and boreal zones are characterized by millions of lakes with complex greenhouse gas (GHG) flux dynamics that depend on their thermal, chemical, and biological environments. Methane often accumulates in the hypolimnion of dimictic lakes (lakes that turn over when thermally stratified), and methane release after ice off and during spring turnover can contribute some 40% or more of the total annual efflux. These dynamics are difficult to directly measure on melting ice due to safety issues. We used the eddy covariance technique to measure methane and carbon dioxide flux in two small (~ 1 ha) dimictic bog lakes in northern Wisconsin that turn over – at least partially – twice per year. Two buoys on the frozen lakes were instrumented with LI-7200 enclosed path gas analyzers to measure CO2 flux and LI-7700 methane gas analyzers loaned generously by Ameriflux to measure CH4, and were allowed to thaw with ice melt to measure GHG flux across all seasons. Large methane efflux events that extended for more than two weeks were observed during lake turnover in spring and fall. As a consequence, instantaneous microclimate explained only 20% of the variability of half-hourly methane flux observations and advanced methods were necessary to understand seasonal GHG flux dynamics. We tested multiple Machine Learning (ML) approaches as recommended by recent methane flux syntheses and are using one lake (Trout Bog) to train the ML models and the other (South Sparkling Bog) to ask if ML-modeled GHG fluxes can be extended across multiple lakes. We anticipate that if the ML models are physics-constrained and can capture lake turnover processes, they will have the potential to predict GHG flux across different bog lakes.

Topic: Natural Climate Solutions
Poster session on: Wed
Poster #24

Balancing climate mitigation benefits from wetlands through water management

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Freshwater wetlands provide a range of climate benefits including evaporative cooling, protection against sea level rise, and long-term carbon uptake and storage. Especially in continually inundated wetlands, aboveground water is important in fulfilling these functions, but comes at the cost of increased methane emissions which reduce the net climate mitigation effects. Alternate wetting and drying methods have been successful in lowering methane emissions from rice, while a reduction in methane emissions has been observed following dry periods in wetlands. Managing water levels in wetlands, where possible, may offer a strategy to maximise climate benefits of wetlands.
With an example wetland that experienced intermittent dry periods during several years, we simulated carbon fluxes without water level changes using random forest models to compare them to observed fluxes measured by eddy covariance. Here we show that although dryout events significantly reduced methane emissions on an annual scale, depending on the duration and depth of the dryout the net climate benefit could be offset by increased carbon loss from ecosystem respiration and/or reduced productivity. Even small increases in productivity resulting from lower water levels were greatly outweighed by carbon losses from higher ecosystem respiration. The effect on the net climate impact, as determined by the greenhouse gas budget in CO2eq differed depending on the metric used to convert methane emissions, i.e. the sustained global warming potential compared to the conversion used by the IPCC (GWP 28) due to the different weighting of methane. Although this method may lower methane emissions, careful control would be needed to avoid turning the wetland into a net carbon source. These results highlight the delicate balance needed for wetlands to achieve net climate benefits, as well as the complexity of how we evaluate natural climate solutions.

Topic: Open Science Session
Poster session on: Mon
Poster #25

Annual variability and landscape scaling derived from an eddy covariance site cluster

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Clusters of flux sites allow us to perform inter-site analysis while controlling for a large degree of variation from local weather and climate. Using geospatial statistics from site clusters in Michigan and Wisconsin, we demonstrated that carbon and sensible heat fluxes were 95% correlated directly outside of their flux footprint and 56% correlated up to a distance of ~35 km. Latent heat energy and momentum fluxes were 83% correlated directly outside of their flux footprint and 40% at a distance of ~130 km. Across a ~160 km watershed in Michigan, there are 11 flux sites, with a 12th just outside the watershed. Using ~100 site-years of data from this cluster, watershed scale variability of fluxes and their drivers are quantified by land cover type. Some exceptions arise from cover types that are intensively influenced by human activities, such as urban and irrigated cropland. Nevertheless, this variability can be used to estimate watershed-level carbon and water fluxes and estimate scaling error in order to answer the question: What are the spatial and temporal changes of fluxes in managed agricultural-forest landscapes?

Topic: Water
Poster session on: Wed
Poster #26

Using model-data fusion to improve terrestrial biosphere model predictions of evapotranspiration partitioning across 12 semiarid Ameriflux sites

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Accurate land surface model (LSM) predictions of evapotranspiration (ET) partitioning are crucial for both numerical weather prediction and projections of carbon-climate feedbacks, particularly in semiarid regions that are hotspots of land-atmospheric coupling. However, studies have shown that while LSMs may be able to capture ET temporal dynamics, they underestimate transpiration (T) to ET ratios. Partitioning ET into T and bare soil evaporation (E) relies on models being able to simulate complex vegetation, carbon (C), and water cycle interactions. Previous studies suggested that phenology and plant hydraulics processes may be responsible for inaccurate LSM T/ET estimates. Here, we test this theory by assimilating vegetation greenness, net CO2 fluxes, and ET data into the ORCHIDEE LSM to optimize vegetation, C cycle, and hydrological parameters across 12 southwestern US semiarid flux tower sites. Specifically, we explore whether the inclusion of phenology and root zone uptake related parameters results in an improvement in modeled seasonal T/ET in comparison to T/ET estimates from two different methods. We aim to test the following two predictions: 1) incorrect growth of vegetation at the start of the monsoon season is predominantly responsible for errors in T/ET predictions; and 2) optimizing parameters that control plant water stress also help to improve T/ET simulations during the dry season. Further, we test whether improvements in T/ET predictions are possible by only assimilating ET, or whether vegetation greenness and/or C flux data are also needed to help constrain coupled physiological and ecohydrological dynamics. Our results suggest that further developments of the phenology schemes in LSMs to better represent semiarid plant functional types are likely needed before the models can be used to reliably estimate semiarid region ET partitioning.

Topic: Natural Climate Solutions
Poster session on: Mon
Poster #27

Investigating CO2 and CH4 Fluxes Across a Heterogeneous Restored Tidal Salt Marsh in the South San Francisco Bay, California, Using Eddy Covariance and Chamber Measurements

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Interpretation of net ecosystem exchange (NEE) measurements of CO2 and CH4 in tidal wetlands is challenging due to effects from tidal activity and heterogeneous landscapes. In this study we are combining eddy covariance (EC) and soil chamber (SC) measurements to understand sources and sinks of CO2 and CH4 and improve NEE partitioning algorithms. The study site is a restored tidal saltmarsh consisting of three main cover types: Spartina foliosa, Salicornia pacifica, and bare mud flats. Three years of EC data show high net removal of CO2 (avg= -425 g C-CO2 m-2 yr-1, SD=45) and low CH4 emission (avg=0.5 g C-CH4 m-2 yr-1 SD=0.3). Then using the SC measurements and generalized additive modeling, we modeled the respiration over a one-year time period to include as a predictor variable in an artificial neural network (ANN) partitioning approach. The best ANN model has an R2 value of 0.24 for about three years of data with an average R2 of 0.46 during the growing seasons. Traditional partitioning approaches such as the Reichstein and Lasslop approaches had R2 values of 0.10 and 0.01, respectively. Partitioning performance increased when water table depth variables were included, highlighting the significance of tidal activity on carbon (C) exchange. The SC measurements also revealed that average daytime soil surface emission of CH4 is greatest from S. foliosa soils (4.87 nmol m-2 s-1, SE= 1.32) as hypothesized, however the highest CO2 emissions were from mud flat (0.544 umol m-2 s-1, SE=0.124) and S. pacifica soils (0.407 umol m-2 s-1, SE=0.095), contrary to previous findings. After restoration, soils in unvegetated areas showed a coarsening of sediment size, potentially allowing for increased oxidation of organic matter or CH4. S. foliosa also grows at lower elevations than S. pacifica, showing the importance of the relationships between wetland plant community, elevation, and C emissions.

Topic: Open Science Session
Poster session on: Wed
Poster #28

The evapotranspiration and carbon exchange of corn on a sandy soil: sensitivity to precipitation events and comparison against other corn eddy covariance measurements

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Maize (Zea mays, hereafter corn) is a global staple crop whose presence is so ubiquitous in some areas that impacts regional climate by increasing atmospheric humidity, known as the “corn sweats”. At the same time, dramatic growth results in acute seasonal carbon dioxide uptake due in part to its water-use-efficient C4 photosynthetic pathway. Corn is grown across a wide range of edaphic and climate variability yet no study to date has synthesized how these differences impact carbon/water coupling across the vegetative growing season. Here we present eddy covariance measurements of net ecosystem carbon dioxide and water exchange in a corn field in the Central Sands of Wisconsin, a sandy end-member of the soil texture continuum. Latent heat flux decreases sharply in the days following large rain events, which have become more prevalent in recent years in Wisconsin due to regional changes in hydroclimate. Carbon dioxide uptake is very tightly coupled to water flux with R2 = 0.74 during daytime periods - more so than at other corn Ameriflux sites. presumably due to low evaporation due to efficient infiltration and soil water transport through sand; soil moisture rarely exceeded 0.2 m3/m3 on a volumetric basis above the 30 cm soil depth. Results suggest a continuum of carbon/water coupling strength in corn ecosystems along an edaphic gradient with implications for resource management and ecosystem modeling.

Topic: Water
Poster session on: Mon
Poster #29

Anticipating the hydrologic consequences of Emerald ash borer invasion in forested wetlands using a sapflux network in the Menominee and Stockbridge-Munsee Tribal Lands

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Black ash (Fraxinus nigra) is an ecologically and culturally important trees species for tribal communities in Wisconsin. Tribes maintain significant landholdings in forested wetlands including those dominated by black ash. These systems have not been a priority for management, but anticipated emerald ash borer (EAB, Agrilus planipennis)-induced mortality has prompted tribal managers to seek strategies and prioritize areas for mitigation.

There is a need to develop guidelines for mitigation by wetland hydrologic type, but the variation of species composition and hydrologic function in these systems have not yet been examined (Palik et al., 2020). Tribal-scale research will direct local management, but the magnitude of changes in wetland hydrology due to EAB damage is unknown and is likely to be highly variable depending on wetland composition. In forested wetlands with minimal groundwater or surface flow inputs, transpiration is likely an important controller of site hydrology (Telander et al. 2015).

Sap flux density and eddy covariance can capture a refined picture of environmental and atmospheric controls to better determine how site hydrology changes following black ash loss, and direct specific management areas for tribal managers. Here, we describe a sap flow monitoring program to estimate tree and stand level transpiration in isolated mixed species wetlands that include black ash, and recent addition of eddy covariance-measured ET to understand water fluxes across these highly variable and threatened systems.

Brian J Palik, Anthony W D'Amato, Robert A Slesak, Wide-spread vulnerability of black ash (Fraxinus nigra Marsh.) wetlands in Minnesota USA to loss of tree dominance from invasive emerald ash borer, Forestry: An International Journal of Forest Research, Volume 94, Issue 3, July 2021, Pages 455–463

Telander, Andrew C.; Slesak, Robert A.; D'Amato, Anthony W.; Palik, Brian J.; Brooks, Kenneth N.; Lenhart, Christian F. 2015. Sap flow of black ash in wetland forests of northern Minnesota, USA: Hydrologic implications of tree mortality due to emerald ash borer. Agricultural and Forest Meteorology. 206: 4-11.

Topic: Open Science Session
Poster session on: Wed
Poster #30

NIRvANA: A comparison of Gross Primary Productivity estimates with indicators of light absorption and light use at Montana wheat and grassland AmeriFlux sites

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Gross Primary Productivity (GPP) partitioned from measurements of gas exchange at eddy covariance towers are widely used to develop relationships between spectral vegetation indices and ecosystem carbon uptake. The reflected near-infrared radiation from plant canopies (NIRv) is proportional to the photosynthetically active radiation absorbed by plants but it is unclear if it succinctly explains changes to GPP in diverse grass canopies subject to seasonal drought or if additional spectral measurements are necessary. Here we test the relationship between NIRv and GPP estimates from multiple flux partitioning approaches at a winter wheat field and a montane grassland in Montana, USA. We also test the use of NIRv in the light response curves used to partition net ecosystem exchange into GPP and ecosystem respiration to understand the impact of light absorption on GPP estimates. We analyze how partitioning approaches impact estimates of diurnal water-use efficiency and light-use efficiency. The resulting ecosystem light-use efficiencies from the different partitioning approaches are compared to the photochemical reflectance index (PRI). The PRI has demonstrated strong correlations with light-use efficiency by its sensitivity to the dissipation of excess light energy by the carotenoids involved in the xanthophyll cycle. We analyze the dynamics of light absorption, light use, and the dissipation of excess light energy during high light environments at these sites using NIRvP and PRI. Our results can help understand the use of multiple tower mounted spectral vegetation indices and how their relationships with ecosystem function can be impacted by landscape diversity and flux partitioning approaches.

Topic: Water
Poster session on: Mon
Poster #31

Wildfire disturbance effects on land surface temperature dynamics

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Wildfire is the most important disturbance agent in boreal forests. Fire and post-fire succession are linked to diverse changes in ecosystem function and structure shaping land-atmosphere interactions for decades. Forests have been shown to minimise differences between land surface and air temperature exerting a surface cooling effect particularly during the growing season when evapotranspiration is high and albedo low. However, how wildfire disturbance alters differences between land surface and air temperatures in boreal forests still remains uncertain. Here, we analyse surface energy balance observations from eddy covariance flux tower sites across fire disturbance chronosequences in the North American boreal biome to identify the main drivers of post-fire changes in land surface-air temperature gradients. We use multi-year observations to quantify changes in important ecosystem properties such as evaporative fraction, aerodynamic conductance, and albedo following stand-replacing fire disturbances. We find that the growing season temperature gradient declined over the three decades after the fire disturbance. Evaporative fraction increased over the same period while no significant trends in albedo and aerodynamic conductance were observed. Our results provide important insights into fire impacts on ground thermal regimes in boreal forests and highlight the reduced capacity of post-fire forests to reduce land surface temperatures during heatwave events

Topic: Water
Poster session on: Wed
Poster #32

Carbon and water flux responses to interstorm drought duration in dryland ecosystems

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In arid and semiarid ecosystems, rain events drive pulses of carbon and water exchange mediated by plant and soil responses to soil moisture availability. Changes to precipitation patterns that alter the supply and demand of moisture will therefore likely impact carbon and water exchanges in these water-limited ecosystems. Although precipitation intensification is increasing the duration of dry intervals between rain events in many water-limited regions, it is unclear how dryland ecosystem fluxes respond to changes in interstorm drought duration. We hypothesized that differences in the sensitivity of ecosystem photosynthesis (GPP) and respiration (Re) to soil moisture stress regulate the response of net ecosystem productivity (NEP) to variability in interstorm drought duration. To test this hypothesis, we synthesized long-term flux records from a global network of dryland sites and examined patterns of ecosystem fluxes during pulse events and interstorm droughts. We used multiple linear regression and random forest methods to quantify the rate of decline in ecosystem fluxes during drydown periods between rain events. Across sites, we observed widespread pulse behavior and found key differences in the patterns of ecosystem photosynthesis (GPP), and respiration (Re) during interstorm periods. Future work will investigate these patterns across gradients in soil texture and plant functional type. Preliminary results indicate the potential for projected increases in interstorm duration to impact the carbon sequestration capacity and water-use-efficiency of rain events in drylands.

Topic: Open Science Session
Poster session on: Mon
Poster #33

Evapotranspiration in the Mid-South US: Estimating crop coefficients with gridMet and eddy covariance observations across 32 field-seasons

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Evapotranspiration (ET) is a key component of the Earth's energy balance and hydrological cycle and understanding its responses to global change would benefit from a simplified estimation technique. While the eddy covariance (EC) method is broadly used to provide actual evapotranspiration (ETa) measurements, a comprehensive network of flux tower data has been missing for different land cover types in the Mid-South US. This study fills this regional gap by (1) obtaining continuous ETa time series by adapting gap-filling methods on latent heat flux data from different land cover and land or irrigation management approaches in this region and (2) estimating crop coefficients (Kc) at these locations using reference evapotranspiration (ETo) from the Gridded Surface Meteorological (gridMET) dataset and the gap-filled flux dataset. This method suggests a test of gridMET, which because of its continuous temporal and wide spatial extent offers an opportunity to scale site-level ET measurements across the region. The land cover of the 15 study sites [32 FS (field-seasons)] ranges from different agricultural landscapes [i.e., rice (16 FS), cotton (3 FS), and sugarcane (7 FS)] to forests [i.e., pine (1 FS) and deciduous broadleaf (5 FS)]. The ET time series showed that rice did not have varying ETa across different irrigation strategies including continuous flood via cascade irrigation and alternate wetting and drying. The average initial, mid, and final growth stages Kc for rice, cotton, and sugarcane were [0.94±0.22, 1.71±0.23, 0.93±0], [1.45±0.79, 1.78±0.14, 0.72±0.03], [1.17±0.58,1.38±0.18, 0.83±0.41], respectively. The pine forest showed the lowest Kc values [0.44, 0.69, 0.20], and Kc values for the deciduous forest were [0.92±0.17, 1.47±0.52, 0.64±0.10]. Most of the inter-annual variability in Kc, estimated as the coefficient of variation (Cv=Standard Deviation/Mean), was observed in the initial growth stage (Cv: 0.18 - 0.55). In particular, cotton and sugarcane revealed high Cv (0.55 and 0.49) for the initial growth stage due to varying meteorological condition over the site-seasons. In our follow-up work with longer time series and a site-by-site inquiry of the drivers of ET, we aim to constrain this variability. Meanwhile, the proposed Kc values can be used to estimate evapotranspiration at similar regions using gridMET ETo. This approach can be a scalable substitute for calculating ETa using the Penman-Monteith approach (FAO 56) with gridMET data as input.

Topic: Open Science Session
Poster session on: Wed
Poster #34

BLUEFLUX: upscaling airborne eddy covariance measurements of mangrove carbon fluxes

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Mangrove ecosystems play important ecological and societal roles around the globe yet, like many ecosystems, mangroves face pressures from development and global change. To protect these ecosystems, blue carbon initiatives have been proposed as a mechanism to support restoration and conservation. The net carbon storage benefits of mangroves is not simply related to CO2 uptake, but also CH4 release, and only sparse measurements at small spatial scales exist to estimate the net climate benefits. BLUEFLUX is a new NASA Carbon Monitoring System (CMS) proposal that will carry out roughly 75 flight hours of airborne eddy covariance over mangrove systems in Florida. The flight hours are split into 6 campaigns, in spring, summer, fall, in 2022 and 2023. The flights will cover different mangrove zones, with varying disturbance histories and at different times of day to capture tidal regime. In-situ chamber and flux tower measurements will be used to evaluate and help interpret the aircraft observations. The measurements will be used to train machine learning algorithms using remote sensing observations to develop a 500-m, weekly gridded CO2 and CH4 flux product spanning the MODIS era (2001-present day). The dataset will be used to understand spatial gradients in mangrove carbon fluxes, their changes over time, and as basis for informing restoration and conservation efforts for a variety of CMS stakeholders.

Topic: Open Science Session
Poster session on: Mon
Poster #35

Impact of Vegetation Structure on the Spatial and Temporal Variability of Radiation Regime and CO2 Uptake in Forests through Fusion of Lidar Measurements and A Canopy Geometric Optical and Radiative Transfer Model

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Complex three-dimensional canopy structure cause large spatial and temporal variation of radiation regimes in forests. Vertical distribution of light transmission and absorption is critical for photosynthesis, evaporation, and carbon update. Complex canopy radiative transfer models have been developed to simulate the impact of heterogeneous vegetation structure on radiation regimes within the canopy. However, these models suffer from accurate structure inputs to drive the model to explicitly assess the spatial and temporal variability of the radiation regime. This study aims to integrate lidar three-dimensional vegetation structure measurements with a canopy geometrical optical radiative transfer (GORT) model to study the spatial and temporal variability of vertical light transmission and absorption. We evaluated the performance of the model by comparing modeled vertical distribution of photosynthetically activate radiation (PAR) transmission and absorption with NEON's field measurements and discussed the pros and cons of each approach. We further analyzed the impact of vegetation structure on the spatial and temporal variability of the photosynthetically activate radiation absorption and CO2 update in all NEON terrestrial forest sites across the continental US.

Topic: Natural Climate Solutions
Poster session on: Wed
Poster #36

Climate forcing consequences of stand-replacing fire in Semi-Arid Subalpine Forests

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The combination of extreme droughts starting at the turn of the century with anomalously high air temperatures, has led to an increase in unprecedented extreme fire events all over the Western US. These stand-replacing fires dramatically alter ecosystem structure, land-atmosphere exchange processes and feedback loops which could potentially exacerbate more extreme drought and aridity. The Thompson Ridge fire in summer 2013 in the Valles Caldera National Preserve in New Mexico burned about 10,000 ha of forest, including a stand-replacing burn in the subalpine mixed conifer US-Vcm site. The long record of carbon, water and energy exchange at this flux-tower site (since 2007), together with the fluxes from a new rapid-response tower established in a nearby unburned mixed conifer site (US-Vcs) in 2015, allows us to explore the consequences of the fire for land-atmosphere exchange processes that may exacerbate changes in climate moving forward. Surprisingly, the burned mixed conifer site returned to being a carbon sink in only 2 years, however it sequestered only 15% of pre-burn NEE. Annual Latent Heat (LE) and Sensible Heat (H) fluxes post-fire were only 85% and 50%, respectively, of pre-burn values. Observations of NEE, LE and H fluxes in the burned mixed conifer site as it recovered were 78% lower, 8% higher, and 50% lower than the nearby unburned mixed conifer forest. In addition, the stand replacing burn significantly altered surface temperatures. Using an energy balance method that extracts the biophysical responses to environmental conditions, we observed that the changes in albedo, surface roughness and canopy conductance following the fire increased surface temperature by up to 5 degrees during the day and reduced it by up to 3 degrees at night. The increase in surface temperature was driven by increased aerodynamic conductance, even though the ecosystem evapotranspiration in burned vs unburned sites increased after fire. We scaled these observations, using the spatial extent of fires in this biome throughout New Mexico to discuss the potential climate forcing consequences of these recent burns to the region.

Topic: Natural Climate Solutions
Poster session on: Mon
Poster #37

Can Vegetation Indices serve as Proxies for Potential Sun-induced Fluorescence (SIF)? A Fuzzy Simulation Approach on Airborne Imaging Spectroscopy data

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In this study, we are testing a proxy for red and far-red sun-induced fluorescence (SIF) using an integrated fuzzy logic modelling approach, termed as SIFfuzzy and SIFfuzzy-APAR. The SIF emitted from the core of photosynthesis aperture and observed at the top-of-canopy is regulated by three major controlling factors: (1) light interception and absorption by canopy plant cover; (2) escape fraction of SIF photons (fesc); (3) light use efficiency and non-photochemical quenching (NPQ) processes. In our study, we proposed and validated a fuzzy logic modelling approach that uses different combinations of spectral vegetation indices (SVIs) reflecting such controlling factors to approximate the potential SIF signals at 760 nm and 687 nm. The HyPlant derived and field validated SVIs (i.e. SR, NDVI, EVI, NDVIre, PRI) have been processed through the membership transformation in the first stage, and in the next stage the membership transformed maps have been processed through the fuzzy Gamma simulation to calculate the SIFfuzzy. To test whether the inclusion of absorbed photosynthetic active radiation (APAR) increases the accuracy of the model, the SIFfuzzy was multiplied by APAR (SIFfuzzy-APAR). The agreement between modelled SIFfuzzy and actual SIF airborne retrievals expressed by R2 ranged from 0.38 to 0.69 for SIF760 and from 0.85 to 0.92 for SIF687. Whereas, the inclusion of APAR improved the R2 value between SIFfuzzy-APAR and actual SIF. This study showed for the first time that a diverse set of SVIs considered as proxies of different vegetation traits, such as biochemical, structural, and functional can be successfully combined to work as a first-order proxy of SIF. The previous studies mainly included the far-red SIF whereas, in this study, we have also focused on red SIF along with far-red SIF. The analysis carried out at 1 m spatial resolution permits to better infer SIF behavior at ecosystem relevant scale.

Topic: Water
Poster session on: Wed
Poster #38

FETCH3: A Tree-Level Hydrodynamic Modeling Approach for Examining Species-Specific Stomatal Regulation at AmeriFlux Sites

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Improving the representation of plant hydraulic behavior in vegetation and land-surface models is critical for improving our predictions of the impacts of drought stress on ecosystem carbon and water fluxes. Species-specific hydraulic traits play an important role in determining the response of ecosystem carbon and water fluxes to water stress. Here, we present plans for the development of the Finite-difference Ecosystem-scale Tree Crown Hydrodynamics model version 3 (FETCH3), a tree hydrodynamic model which builds upon its predecessors FETCH and FETCH2. FETCH3 simulates water transport through the soil, roots, and xylem as flow through porous media. The model resolves water potentials along the vertical dimension, and stomatal response is linked to xylem water potential. The tree-level model is scaled to the plot scale based on the species composition and canopy structure of the plot, allowing the model to be validated using both tree-level observations (sap flux) and plot-level observations (eddy covariance). We will collect data from multiple sites that have both sap flux and eddy covariance measurements for analysis. The Predictive Ecosystem Analyzer (PEcAn) will be used for optimization of the hydraulic parameters in FETCH3 for different plant types in multiple sites. We plan to use this new modeling framework to examine the interactions among water stress, species-specific hydraulic strategies, and stomatal regulation across different species and ecosystem types.

Topic: Water
Poster session on: Mon
Poster #39

Canopy structural change following disturbance modulates forest microclimates

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Forest structural diversity and community composition are key forest attributes that play a role in regulating forest microclimates. When either or both attributes are affected by disturbance, soil temperature, soil water content, and light acquisition may be affected, potentially altering forest microclimates. It is however unclear which structural or compositional components, when changed or to what extent, exert the strongest controls over microclimatic change. To address this question, we used data from the first two years of a large scale, manipulative stem-girdling experiment in northern, lower Michigan to examine how multiple components of structural diversity and community composition respond to varying levels of disturbance severity, and then to test the individual and combined effects of those components on forest microclimate response. We found not all structural and community variables changed significantly from pre- to post disturbance, but we did find significant change in canopy cover (e.g. gap fraction), canopy complexity (e.g. canopy rugosity, effective number of layers), species richness, and stand structure (e.g. gini coefficient, tree size diversity index, basal area). Microclimate response was best described by changes in canopy cover. We found relationships to be linear, and though statistically significant, correlations were weak with loss of canopy cover correlated with mean soil temperature (R^2 = 0.10), mean volumetric water content (R^2 = 0.19), and the standard deviation of volumetric water content (R^2 = 0.13). Multivariate approaches combining changes canopy structure, stand structure and community composition could better inform our understanding of these connections and resolve additional uncertainty in forecasting and modelling forest microclimatic response to disturbance.

Topic: Open Science Session
Poster session on: Wed
Poster #40

Data Support for Site Teams | How to ready your site for ONEFlux processing

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The AmeriFlux Management Project (AMP) provides a number of data services for site teams. Our semi-automated QA/QC pipeline provides a suite of quality checks for a site's continuous flux/met data that is uploaded in the FP-In standard format. Upon successful completion of QA/QC review, AMP acquires a Digital Object Identifier (DOI) for the resulting AmeriFlux BASE data product and makes it available on the AmeriFlux website. Download statistics are provided to the site team. Starting in September, site teams can share their site's data, including BASE, under the new AmeriFlux CC-BY-4.0 License.

For site teams that share their data under the CC-BY-4.0 license, AMP now offers ONEFlux processing that gap-fills and partitions flux/met data and provides uncertainty analyses. The resulting FLUXNET data product is compatible with the FLUXNET2015 dataset and will be eligible for future global synthesis efforts. Steps required to prepare a site for ONEFlux processing include: submitting required ONEFlux flux/met variables for publication as BASE, updating height and instrument model information via the online Variable Information tool, and indicating the site's representative BASE variables using the new Variable Aggregation BADM. Additional details are provided in this poster.

Biological, Ancillary, Disturbance, and Metadata (BADM) that support continuous flux/met data can also be submitted to AMP for publication. BADM contain site characteristics (e.g., latitude / longitude, vegetation and climate classification), variable information (e.g., height / depth, instrument model), and ecological data collected at the site (e.g., canopy height, LAI, soil characteristics). New online webpages describe available BADM groups and variables (https://ameriflux.lbl.gov/data/badm/badm-standards/). Via this online resource, site teams can now customize a CSV reporting file template that contains only variables of interest. Additionally examples of how to report BADM are available in these new webpages.

Topic: Open Science Session
Poster session on: Mon
Poster #41

New (and Improved!) AmeriFlux Data Products and Services for Data Users

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The AmeriFlux Management Project (AMP) disseminates standardized flux/met and ancillary data products from 400 AmeriFlux sites. Nearly 350 sites, over 275 with data, have elected to release their data under the CC-BY-4.0 data license. The CC-BY-4.0 license was also adopted by most sites in FLUXNET2015, which was updated in February 2020. AmeriFlux data distribution under this new license will begin in 2021.

The AmeriFlux BASE data product is continuous half-hourly/hourly quality-controlled flux and meteorological (flux/met) data provided by site teams and formatted in the Flux Processing (FP) global standard. Data for each site is assigned a DOI. Data users can search over 2,600 site-years of BASE data by 133 variables spanning 30 years (1991-2021) on the AmeriFlux website.

Supporting Biological, Ancillary, Disturbance, and Metadata (BADM) are also available and contain site characteristics (e.g., latitude / longitude, vegetation and climate classification), variable information (e.g., height / depth, instrument model), and ecological data collected at the site (e.g., canopy height, LAI, soil characteristics). New online documentation describes available BADM groups and variables (https://ameriflux.lbl.gov/data/badm/badm-standards/).

The FLUXNET data product, which is compatible with the FLUXNET2015 dataset, is generated with the ONEFlux processing codes that gap-fill, partition fluxes, and perform uncertainty analysis. An evaluation version of the data product is available for over 60 sites. AMP has integrated ONEFlux into the AmeriFlux data processing pipelines as described on new webpages (https://ameriflux.lbl.gov/data/data-processing-pipelines/). The production release of the FLUXNET data product for over 20 AmeriFlux sites is scheduled for September 2021.

To support the new CC-BY-4.0 license and upcoming production FLUXNET release, we have revamped many data-related pages on the AmeriFlux website, including Download Data, Site Search, Site Sets, and Data Availability. Learn more details in this poster!

Topic: Water
Poster session on: Wed
Poster #42

Comparative Analysis of Evaporative Water Use Between Annual Row Crops and Perennial Systems

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Concerns about the environmental impact of continuous annual row crop production have generated widespread interest in practices that maintain continuous vegetative cover. These include perennial grain crops such as kernza, perennial living mulch systems, in which row crops are sown into a perennial ground cover, reforestation, and restoration of prairie vegetation, either in strips or whole fields. The effect of such practices on local and regional hydrology is an open and important question. There is solid evidence that infiltration is higher in such systems than in adjacent conventionally cropped fields, but less is known about their relative evaporation rates to the atmosphere. We examined multiple years of eddy covariance data from two Ameriflux sites (Rosemount and MOFLUX) where there are nearby flux towers in both annual crops and perennial prairie. The prairie systems, both restored and native, exhibit substantially lower annual ET than nearby annual row crop systems, by 20-25%, despite the continuous presence of vegetation. This is primarily due to much lower evaporation rates in the spring, which in turn is due to higher albedos and later green up. Conversely, a perennial living mulch system (corn/soy planted into kura clover) at our MN site exhibited higher annual ET than either the restored prairie or the conventional annual cropping systems, due to the vigorous early season growth of the clover. We conclude that generalizations about the impact of perennial vegetation on annual evaporative loss are not tenable; results depend, among other things, on the phenology and radiative properties of the various systems.

Topic: Open Science Session
Poster session on: Mon
Poster #43

Climate drives modeled forest carbon cycling resistance and resilience in the Upper Great Lakes Region, USA

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Forests dominate the global terrestrial carbon budget, but their ability to continue doing so in the face of a changing climate is uncertain. A key uncertainty is how forests will respond (resistance) and recover from (resilience) to rising levels of disturbance of varying intensities. This knowledge gap can optimally be addressed by integrating manipulative field experiments with ecophysiological modeling. We used the ED-2.2 model to project carbon fluxes for a northern temperate deciduous forest subjected to a real-world disturbance severity manipulation experiment. ED-2.2 was run for 150 years, starting from near bare ground in 1900, and subjected to three disturbance treatments under an ensemble of climate conditions. Both disturbance severity and climate strongly affected carbon fluxes, and interacted with one another. We then calculated metrics of functional ecosystem stability. Modeled gross primary production exhibited a mean resistance of -0.13, -0.23, and -0.42 (unitless) in response to increasing disturbance severity of 45%, 65%, and 85% mortality, respectively; and resilience of 0.002, 0.004, 0.008 (yr-1) respectively. This pattern held true for other carbon fluxes, meaning that in general simulated GPP declined more initially but recovered more quickly from higher mortality. Notably, however, heterotrophic respiration responded more slowly to disturbance, and its highly variable response was affected by different drivers. This work provides insight into how future conditions might affect the functional stability of mature forests in this region under ongoing climate change and changing disturbance regimes.